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Groundwater Exploration Using Vertical Electrical Sounding Technique in Parts of Gindiri, North-Central Nigeria

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Abstract
This research involved the use of electrical resistivity technique which is considered most appropriate for subsurface investigation of structures and/or lithologies associated with the occurrence of groundwater; to investigate the geo-electric characteristics of the subsurface formations that underlie the study area. The aim was to provide a data base for sustainable groundwater development in the study area. The geophysical investigation involved the acquisition of twenty two (22) vertical electrical sounding (VES) data via the ABEM terrameter SAS 300C model using the Schlumberger configuration. These were quantitatively and qualitatively analysed using partial curve matching and computer iteration to obtain subsurface information in the study area. The results obtained from the interpretation of the VES data show earth models with geo electric layers ranging from three (3) to four (4). The representative type curves are H, A, HA, QH, HK and KH types. The subsurface is made up of four layers, namely the topsoil, the weathered layer, the partially weathered/fractured bedrock and the fresh bedrock, with the weathered layer and the partially weathered/fractured bedrock layers constituting the aquifer units of generally low, medium and high groundwater yielding capacities.
Keywords: Geophysical, Aquifer, Weathered, Fractured, Groundwater.

1. Introduction

The study area is underlain by rocks of the Basement Complex and groundwater tends to be highly limited in extent in Basement and other crystalline rock terrains (Offodile, 2002). In Basement Complex terrain, groundwater occurs either in the weathered mantle or in the joints and fracture system in the unweathered rocks (Olorunfemi and Olorunmiwo, 1985; Ako and Olorunfemi, 1989; Olayinka and Olorunfemi, 1992).These rocks lack primary porosity where groundwater could accumulate for exploitation. Therefore, for these rocks to store water, there must exist in them secondary porosity, which invariably results from geodynamic processes such as weathering and fracturing. However, the spatial distribution and depth of this kind of porosity vary from one location to another and this sporadic nature of groundwater occurrence makes siting of boreholes in this geological terrain difficult (Ramadan, 2010). However, the electrical resistivity method, as a geophysical tool, has become increasingly successful in the search for groundwater in areas underlain by such rocks (Keary et al., 2002).

Gindiri is referred to as a training centre because within it is situated the following citadels of learning; Teachers Training college, Boys Secondary School, Girls High school others include Theological School, Comprehensive Secondary School, School for the Blind and College of Education. Consequently, there is a constant growth in the population of which a huge number depend on groundwater for their domestic, commercial and industrial purposes. This is because of the inconsistency in supply of treated water by government, unreliability of surface sources as most of the stream channels are seasonal and so on. It is in light of this, that this research was carried out with the sole aim of investigating the subsurface geo electric layers in order to determine the aquiferous zones which would help immensely in the groundwater development of the area.

2. Location of the study area

The study area is located in Mangu Local Government Area (LGA) of Plateau state, north central Nigeria (fig. 1). It falls within the Federal survey sheet tagged “”Maijuju 169 and is bounded by latitude 09^0 34’.N and 09^0 36’N longitude 09^0 12’E and 09^0 15’E respectively. it covers a total area extent of about 64 km^2 and is generally accessible through the Mangu – Pankshin express way

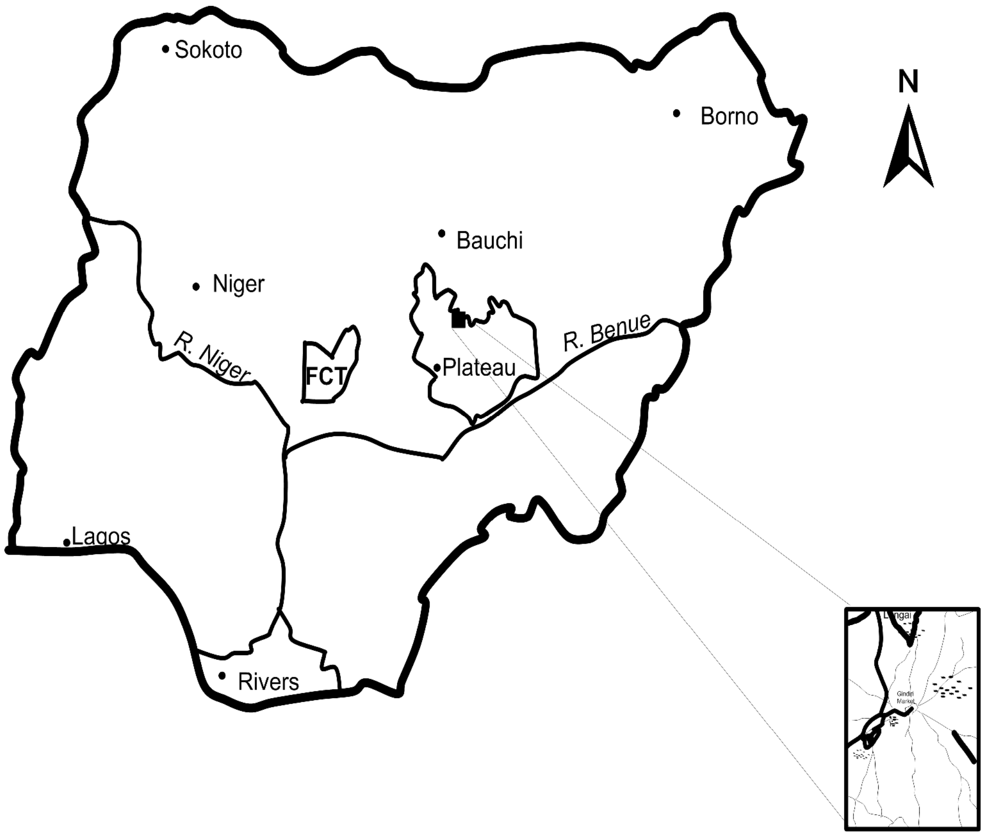

Fig. 1 Map of Nigeria showing the study Area

3.Physiography and Geology
The study area is generally undulating with valleys and outcrops of crystalline basement rocks, precisely the Hornblende Biotite granites located at north-eastern flank of the research area and the Migmatitic banded granite occupying the north, west , south and extreme south- eastern area (fig.2). Gindiri and environs is drained by minor streams and rivers which are trellis patterned typical of the Basement environment and are tributaries of the River Lere flowing in from the northern part of the study area characteristically seasonal. The Lere river flow towards the south-eastern part of the study area with tributaries towards the western, southern and south-western parts(Fig.2) and eventually join up as the headwater of the Gongola river on the Jos Plateau.

4. Materials and Method
In order to achieve the aim of this research, a preliminary survey using remote sensing technique was conducted to identify the suitable locations for sounding. Afterwards, twenty two (22) vertical electrical sounding (VES) points were engaged within the study area using the ABEM terrameter SAS 300C model. These data acquisition points were strategically selected and spread within the study area, employing the Schlumberger electrode configuration in which current was introduced into the ground through a pair of current electrode and the resulting potential difference were obtained through a pair of potential electrode and then recorded. The data were qualitatively interpreted using the partial curve matching techniques and further optimized by computer iteration.

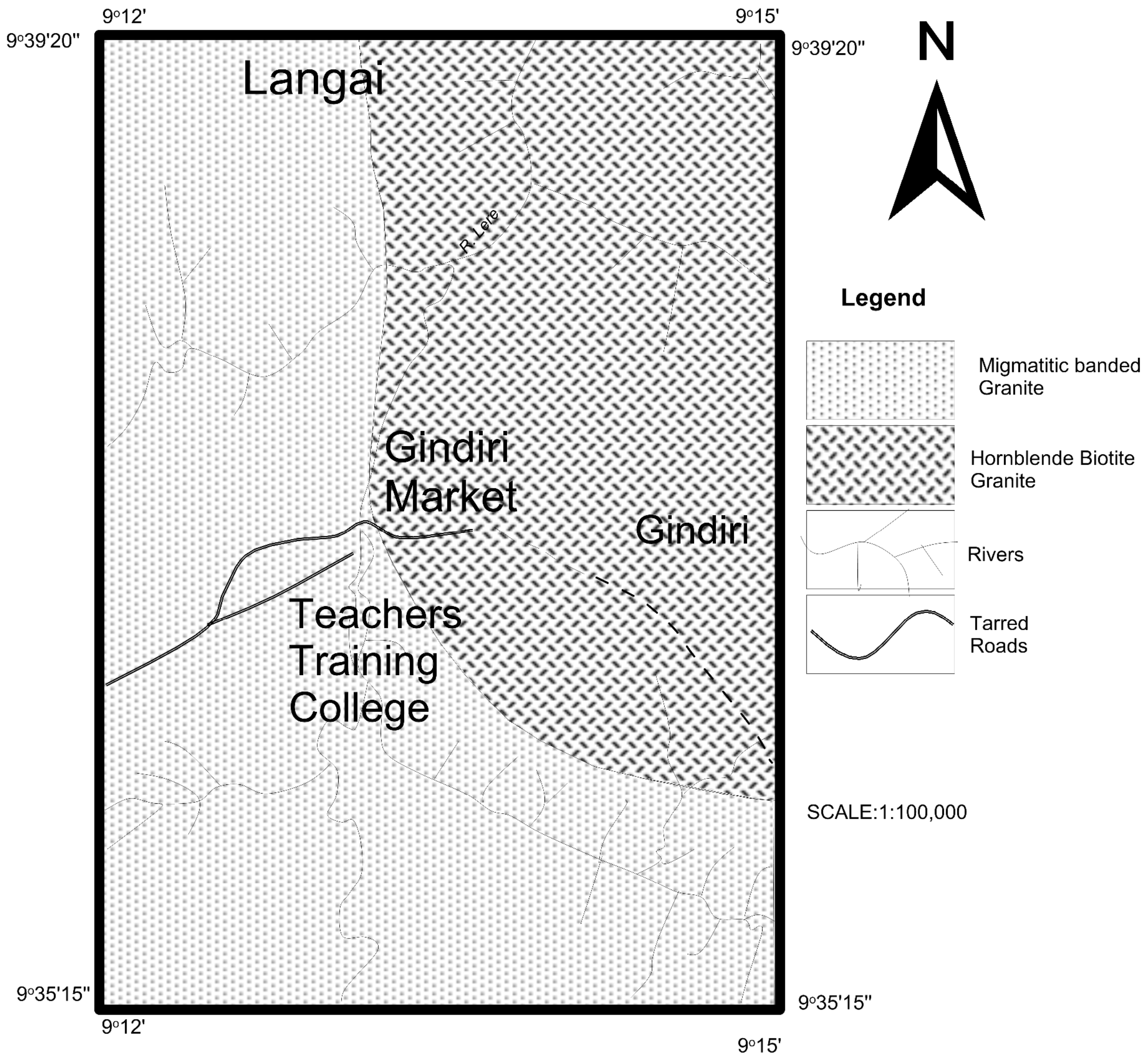

Fig.2 Map showing rock types and Drainage

5. Results and Discussions

Generally, the interpretation revealed 3-4 geoelectric layers. The first layer which depicts the top soil has a thickness range between 0 - 2.5m and resistivity range from 117-504 Ω m. The second layer which is the weathered basement with thickness range between 2.0 m – 16 m and resistivity values ranging from 104 – 1171 Ω m. Similarly, the third layer represents slightly weathered/ fractured basement with resistivity values of 205-2103 Ωm and thickness range between 18m -23m, where as the resistivity value range of the fourth layer presumed to be the fresh basement is from 307 – 5545Ωm.

Table 1: Summarized Results of the VES Locations

S/N	Sounding Location	Notation	Curve type	No. of Geoelectric layers	Aquifer Thickness (m)	Groundwater Potential	Remark
1	L1	P1>P2<P3	H	3	12	Medium	
2	L2	P1>P2<P3	H	3	15	Medium	
3	L3	P1>P2<P3	H	3	23	High	drillable
4	L4	P1<P2<P3	A	3	14.1	Medium	
5	L5	P1>P2<P3	H	3	15.6	Medium	
6	L6	P1>P2<P3	H	3	5.8	Low	
7	L7	P1>P2<P3<P4	HA	4	6	Low	
8	L8	P1<P2<P3	A	3	18	Medium	
9	L9	P1<P2<P3	A	3	2	Low	
10	L10	P1<P2<P3	A	3	2	Low	
11	L11	P1>P2<P3<P4	HA	4	10.1	Low	
12	L12	P1<P2<P3	A	3	9.3	Low	
13	L13	P1>P2<P3	H	3	13.2	Medium	
14	L14	P1<P2>P3<P4	KH	4	21	High	Drillable
15	L15	P1<P2<P3	A	3	11	Medium	
16	L16	P1>P2>P3<P4	QH	4	4	Low	
17	L17	P1<P2>P3<P4	KH	4	12	Medium	
18	L18	P1>P2<P3	H	3	6	Low	
19	L19	P1>P2<P3	H	3	6	Low	
20	L20	P1>P2<P3	H	3	10	Low	
21	L21	P1>P2<P3	H	3	2	Low	
22	L22	P1>P2<P3>P4	HK	4	16	Medium	

The results of the twenty two (22) vertical electrical sounding locations are summarized on table 1 above.

According to Olayinka and Mbachi in 1992, the H-type curve typifies a Basement Complex environment, with a low resistivity intermediate layer underlain and overlain by more resistant materials. In concurrence, sixteen (16) out of the twenty two (22) schlumberger curves obtained from the study area show 3-layer A and H-type curve while, the remaining six (6) exhibit a 4-layer, QH, HK and KH-type of curves. In the study area, the lithology varied from top soil to weathered layer to weathered/fractured basement and fresh basement and the high groundwater potential locations are characterised by low resistivity, and possibly high porosity and permeability with an enormous aquifer thickness; in most cases, the highest groundwater yield in basement terrain is found in areas, where thick overburden overlies fractured zones (Olorunniwo and Olorunfemi, 1987; Olorunfemi and Fasuyi, 1993) as displayed on locations three (L3) and fourteen (L14) located on the central part of the study area with aquifer thicknesses of 23m and 21m respectively. However, locations with medium groundwater potential areas are L1, L2, L4, L5,L8 others include L13,L15,L17 and L22 as displayed on Table 1 above, characterized by A,H, HK and KH type curves with aquifer thickness ranging from 11-18m. On the other hand, the VES points at L6,L7,L9,L10,L11,L12,L16,L18,L19,L20 and L21 are considered low groundwater potential areas with aquifer thickness ranging from 2-10.1m and signatures represented by the A, H and HA type curves.

6. Conclusion

The application of the Vertical Electrical Sounding in groundwater development cannot be over emphasized if the sinking of dry boreholes is to be avoided. With respect to the subsurface characteristics of the research area, L3 and L14 are considered the best points to site a borehole where adequate supply of water would be guaranteed all year round. in addition, L1,L2,L4,L5,L8,L13,L15,L17 and L22 could also be productive taking into account the fact that the aquifer thicknesses in these locations range from 11-18m.

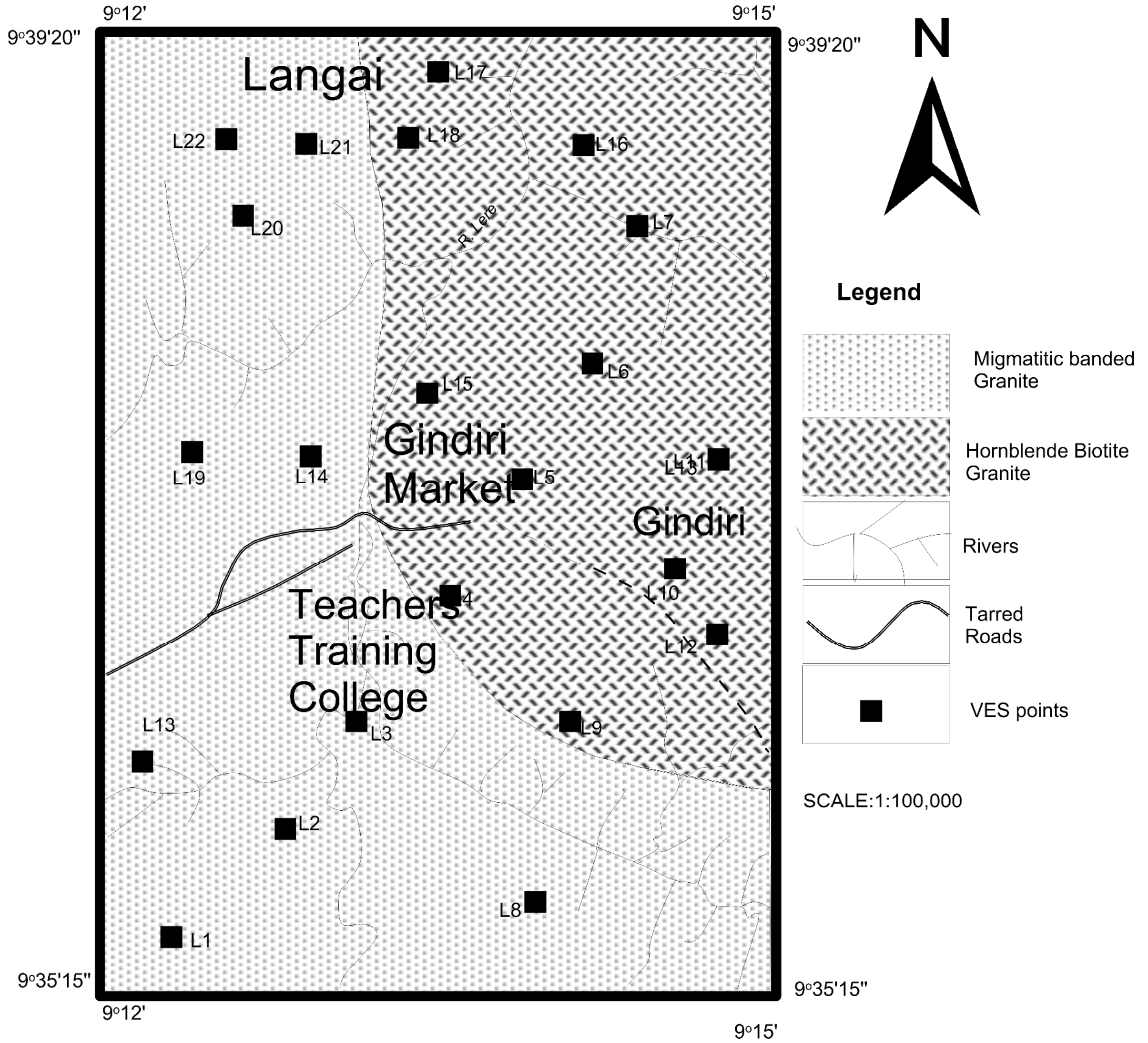

Fig.4 Map showing VES points/Data Acquisition Map

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